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ABSTRACT

Considering the rapid advancements in scientific knowledge and technological improvements, this paper calls for a reorientation of the curriculum and instruction of science education in Japan. The document encourages the development of a science education program which focuses on a few major concepts and then teaches children how to think rationally. The bulk of the paper contains lists of competencies required for this new approach to science curriculum and instruction. It suggests that the new thrusts involve: (1) national structures; (2) the culture and society; (3) career potentialities; (4) science and technology education; (5) science education objectives (including knowledge, problem solving and process skills, and attitudes and values); (6) curriculum development that reflects societal changes; (7) resources and facilities; (8) inservice education; (9) new approaches to teaching science content; (10) learning processes, and (11) evaluation. (TW)

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Open Competence on Science Education

Curriculum and Instruction

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Paper presented at the United States-Japan Seminar on Science Education (Honolulu, HI, September 14-20, 1986).

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SE 048 345

OPEN COMPETENCE ON SCIENCE EDUCATION
Curriculum and Instruction

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JAPAN

The study group meeting on Science Curriculum and Instructional Materials Development (Bangkok, November 1981) while discussing the concept of "open competence" observed:

> "We are in an age of rapid changes in the natural sciences and social situations. In order to adapt to the rapidly changing and progressing age and to contribute to the socio-economic progress, it is important for all the students to acquire certain competencies and attitudes to solve problems, appropriately process fast-expanding information, and think creatively. For education to assist in this, school science education programs will have to provide for teaching-learning experiences through a variety of methods which will help develop concepts and skills which are flexible and applicable to a wide variety of situations rather than limited in scope."

This requires an assessment of the history and philosophy of science, technology and society. Analyses of the nature of present society, curriculum development and teaching contents, methodology and evaluation in a modern scientific, technological, industrialized society must be made. This implies further that teachers and educators at the district and school levels must assess the needs of the particular society and the individuals they serve while being aware of the complexities and idiosyncracies of the society of the nation.

I. The Nature of Society and Science Education

We are living in a world which has shrunk in scope and is changing at an accelerating rate. Advances in science have contributed to many of these changes. The ability of scientists to generate new knowledge is one of our major socio-cultural-ecomonic assets. The support of research to develop more knowledge has in many instances become a political issue. The interaction of science and technology has brought about changes in our way of living. The production of new knowledge and its importance to the progress of our culture make increasing demands upon the science curriculum. They also influence the goals of instruction. No longer is it possible to

SE 041 345

teach a child in school all that he should know in life; rather, we must focus on a few concepts that may be widely generalized and then teach the child to think rationally. The following observations and analyses are only illustrative of ways in which present conditions within our society influence the character of science teaching.

1. Competence on National Structures

   (1) National system of government with respect to science and education,

   (2) Constitutional and legal rights of people with respect to schooling and sciencing,

   (3) Authority for nature and scope of participation in science and technology and in education,

   (4) Controls and influence excercised over curriculum,

   (5) Research and development funds, planners, and

   (6) Support of innovation in Science and Education, policies, regulations, financing, curriculum standards, teacher training, instructional materials, evaluation.

2. Competence on the Culture and Society

   (1) The fundamental values of the people as a nation,

   (2) The mores and traditions of the citizens,

   (3) Political power structure,

   (4) The cultural, social and economic problems and issues,

   (5) The public opinion and attitudes of people on scientific and environmental issues and matters, and

   (6) Expectations and demands on science and schools: purposes, functions, programs, policies, practices, courses, teachers, facilities.

3. Competence on Career Potentialities

   (1) Current career choices and plans,

   (2) Occupational patterns in the nation,

   (3) Occupational trends, locally and nationally,

   (4) Mobility among young persons,

(5) Opportunities for science for all education in community,

(6) Extent of continuation in schooling, and

(7) Manpower requirements, resources, utilization and training.

4. Competence on Science and Technology Education

(1) To further strengthen the development of scientific attitudes, skills and understanding,

(2) To raise the intellectual competence and creativity, and exploration of the problems,

(3) To improve the material and cultural conditions of people's lives,

(4) To develop the productive potential of society in the full utilization of the natural and human resources,

(5) To become an integral part of our cultural and spiritual heritage, and

(6) To meet the deepest needs of human nature which manifests itself as the desire for beauty and truth.

5. Competence on Science Education's Objectives

(1) Knowledge; product of science, facts, information, phenomenon, terminology, trends, sequences, classification, categories, criteria, principles, rules, laws, formulas, symbols, signs, concepts, theories, structure of theories and concepts and their interrelation. Knowledge of scientific research and an accumulated and systematized body of knowledge and a system of behavior for acquisition of knowledge,

(2) Problem-solving and process skills

Problem solving skills

a. Longing to know,

b. Questioning, sensing, recognizing and defining the problem,

c. Search for data and their meaning, hypothesizing,

d. Demand for verification, determining the type of study,

e. Collecting data, judging the adequacy and accuracy of information and data,

f. Drawing conclusion and consideration of consequences, and

g. Communicating results of the inquiry.

Process skills

Observe, describe, make, measure, manipulate, identify, classify, record, compare, relate, interpret, infer, design and conduct of observation and experiments, make assumption, control variables, formulate models, and hypotheses.

Ways of thinking

a. Inductive thinking and deductive thinking,

b. Analytical thinking and synthetical thinking,

c. Divergent thinking and convergent thinking

d. Horizontal thinking and vertical thinking,

e. Intuitive thinking and logical thinking,

f. Imaginative thinking and creative thinking,

g. Dreaming, playing and productive thinking.

Communication skills and information processing

a. Identify, locate and utilize sources of information,

b. Gather descriptive and qualitative information,

c. Gather needed data which have been generated by others from a variety of sources,

d. Records observations accurately and organizes data and ideas in ways that enhance their usefulness,

e. Classify, analyze and utilize relevant information,

f. Select, decide on scope and nature of content, simplify scientific information from primary sources and translate into appropriate languages, and

g. Communicate with others, orally and in writing, in a manner that is consistent with his knowledge of scientific conventions and that facilitates the learning of his readers or listeners.

(3) Attitudes and values

Being intrigued by objects and events.

Being aware of and responding in a positive manner to beauty and orderliness in his environment.

Habitually applying a rational and creative thinking process when attempting to explain discrepant events.

Recognizing the limitations of scientific modes of inquiry and the need for additional, quite different approaches to the quest for reality.

In an honest and objective manner, conducting and reporting the results of his investigations.

Willingly subjecting his data and ideas to the criticism of his peers.

Having a critical, questioning attitude toward unsupported inferences, hypotheses and others.

Self-reliance, positive self-confidence or self-concept on the judgement of ideas.

Respect for other's judgement and ideas.

Patience or tolerance for differences and disagreements from others; openmindedness.

Courage and willingness for taking the responsibility for the judgement and ideas.

Sensitivity to changes and new problems.

Awareness of social and national development appreciating the interrelatedness of science, technology and society.

Love for nature as well as human beings.

Seeing science as an important part of our culture, as an approach to solve human and social problems, as a process as well as a product.

Understanding and recognizing science as a creation of cooperative work.

Seeing science as a critical factor for the improvement of human welfare as well as the technical development and as other's that give rise to an unfavorable environment such as the widespread pollution of air, water, and soil.

6. Competence on Curriculum Development in Science Education

We must recognize that as science and society change, science education in schools needs to be re-evaluated and made consistent with newer development. From time to time, the goals of science instruction, as well as the content and organization of the science curriculum, must be reviewed and the balance corrected between the demands of the modern age and the state of the curriculum. The following developmental outlooks may be used by school teachers and personnel to focus upon curriculum improvements in science.

(1) Society

Agricultural	Industrial	Post-Industrial

(2) Value

Democracy	Economical Scientific Growth	Love for Human Beings

(3) Goals

Interaction	Competition	Social Welfare Self-Development

(4) Trends

Stability Balance	Centralization Specialization	Informalization Internationalization

(5) Curriculum

Experimental	Disciplined	Inter-Disciplined

(6) Taxonomy

Reflective Thinking	Knowledge	Creation
Social Problem Solving	Competency	Affection

(7) Academic Backgound

Pedagogy	Natural Science	Science
	Learning Psychology	Technology
		Sociology
		Anthropology
		Psychology
		Pedagogy

(8) Materials

Loosely Structured	Highly Structured	Modular Structured

(9) Contents

Foods	Biology	Plant and Animals
Cloth		
House	Physics	Matter and Energy
Environmental		
Health	Chemistry	Earth and Universe
Transportation		
Communication	Earth Science	Science and Technology
Agriculture		
Nutrition		Scientific-Technological Society
Industry		

(10) Learning

Project method	Inquiring a discipline	Self-pacing
Learning by doing		Group project

(11) Teacher's Role

Assisting	Directing	Managing

(12) Teaching Techniques

Problem Solving	Lecture	Practical tasks
	Discovery	Doing Science

7. Competence on Resources and Facilities

(1) The Staff

Number, Specialization, Talents, Interests, Assignments, Inservice and Professional Activities, Staff Meetings and Conferences

Type of Staff Activities
Administrator, Supervisor, Inspector, School Couselor, Science Consultant, Special Teachers, Teacher, Helping Person

(2) Building, Equipment, Facilities, Farm, Field

(3) Instructional Materials

Nature and extent, Availability, Case of Use, Procedures of Policy Making and Selection, Budget Provisions

(4) Professional Literature

8. Competence on Inservice Education

(1) Programs

a. Remedical programs of untrained teachers

b. Upgrading programs of untrained teachers
Teaching Unit Plan Workshop
Classroom Teaching Workshop
Experiment and Field Workshop
Materials and Aids Production Workshops
Evaluation Materials Workshop

c. Updating knowledge and observation and experimental skills--programs of trained teachers

d. Programs for special needs

e. Curriculum development programs

f. Instructional leadership programs

g. International science workshops

(2) Activities

a. Lecture

b. Radio, T.V., Teacher's programs

c. Illustrated lecture

d. Reading teacher's books

e. Demonstration

f. Classroom observation

g. Interviewing

h. Brainstorming and group discussion

i. Role-playing

j. Guided practice

(3) Types

a. National level programs

b. Local level programs

c. Seminars in college and university

d. Courses in science centers and ecuational centers

e. Education through radio and T.V.

f. Education through reading science education magazines and books

g. Updating programs in schools

h. Workshop and meeting sponsored by associations and societies

i. Inservice projects sponsored by foundations

j. Workshop and meeting sponsored by material production companies

(4) Competence on Developing a Teaching Unit

a. Behavioral objectives and teaching contents

b. Preparation of equipment, apparatus and materials

c. Knowing the child's previous experiences

d. Motivation of learning

e. Presentation and sequences of new learning experiences

f. Organization of learning

Sensing and defining the problem

Collecting and interpreting the data

Formulation of tentative hypothesis

Plan of experiment and gathering the data

Drawing conclusions

Application to new situation

g. Teaching mode

Lecture, Guided Discovery, Discovery

h. Teaching-learning activities

Lecture-discussion

Teacher demonstration

Small group discussion

Self-paced activities

Group activities

Laboratories

i. Teaching aids

Textbooks

Experimental worksheets

Pupil activity workbooks

T.V. programs

Films, OHP, etc.

Science reading materials

Models and charts

Raw, natural and used materials

Equipment and apparatus

Microcomputers

j. Place of teaching and learning

Laboratories

Classroom

Lab-classroom combination

School grounds

Outdoor study areas such as school gardens, etc.

Science trips away from school to museums, science centers, etc.

Field such as school grain-cereal field

Field trips to parks and natural areas

k. Experiment

The number of experiment

The purpose of experiment

The method to be adopted

The mistake and errors of experiment

Precautions to be observed

Method of tabulating the results

Any question that may help in reaching to desired conclusion

l. Teaching-learning process

Appropriateness of contents

Level of difficulty

Sequence of learning and reactions of students

Readiness and cognitive development

Drives, interests and goal setting

Behavior and skill modification

Process of reconstructing experience into cognitive, psychomotor affective development

Development and cultivation on problem solving skills and information processing

Development sensitivity, creativity, and decision making

m. Teaching strategies and techniques

Question	-Focusing experiences
Presentation	-Sensory experiences
Group discussion	-Data-gathering
Criticism	-Processing experiences
Comment	-Conceptualizing
Explanation	-Confrontation
Nomination	-Experiences
Asking	-Critical investigation
Suggestion	-Evaluation of learning
Admire	
Scold	-Summarizing the learning
etc.	

n. Formative evaluation

Cognitive growth

Processes and skills

Attitudes

Methods

- -paper and pencil test
- -short answer test
- -essay test
- -interview to students
- -student's works and inventions
- -student's scientific studies

o. Summarization

p. Lesson evaluation

Planning

Processing

Evaluation method

II. The Nature of the Learners and Science Education

The characteristics of the learner influences not only the choice of subject matter for the curriculum but also the instructional conditions under which the learner attains the goals of learning. One purpose of a curriculum is to provide a design for relating teaching procedures to the intellectual growth, including the skills and attitudes of the individual.

If the curriculum is to promote intellectual achievement, it needs to be organized and sequenced in terms of the growth and developmental characteristics of young people. The cognitive growth of the individual depends upon the structure and process of the curriculum. As the student learns, acquires verbal, symbolic, and attitudinal mediators he moves through phases of intellectual development, assuring an even increasing potential for further intellectual achievement.

1. Competence on Objectives

(1) Intellectual and creative development

a. levels of readiness

b. capabilites and potentialities

c. level of achievement

d. level of deficiencies

e. status of cognitive development

f. experimental background

g. special talents, absorbing interest

(2) Emotional, social and moral development

a. mental health status

b. self-directiveness

c. development tasks

d. drives, needs, willpower

e. basic need of human being

f. personality

g. moral traits

h. attitude, relations with others

i. cooperation, thankfullness

(3) Physical development

a. health status

b. body development

c. family genetic history

d. physical abnormalities

e. motor skills

f. diseases

2. Competence of Teaching Content

(1) Appropriate knowledge; facts, principles, structures

(2) Method of inquiry and discovery of knowledge

(3) Selecting content for achieving objectives

(4) Organizaion of content and learning experience

(5) Sequence and scope of area or domain of study and reactions of students

(6) Appropriateness of content

(7) Level of difficulty

3. Competence on Students

(1) Numbers, births, age distributions

(2) Race or ethnic background

(3) Socio-economic status of family, social class

(4) Aspiration, educational level of parents

(5) Cultural and intellectual climate

(6) Personal relations

(7) Emotional climate

(8) Nature and extent of disadvantagedness

(9) Nature of peer culture

(10) Opportunities and experience for scientific and technical activities

(11) Dropouts: rate, causes, characteristics school status

4. Competence on Student Growth

	Level 1	Level 2	Level 3
(1)	Processes		
	find	examine	generalize
	gather data	organize data	formulate hypotheses
	make	construct	deduce
	illustrate	compare	reorganize
	measure	estimate	make conceptual models
	identify	identify the variables	
(2)	Attitudes		
	enjoyable	open-minded	weighing evidence
	interest	courageous	constructive in criticism
	egoistic	curious	
	trial and error	cooperative	
(3)	Knowledge		
	facts	trends	principles
	information	classification	concepts
		sequences	generalizations
		relation	

5. Competence on the Learning Process

(1) Readiness and developmental levels

(2) Motivation, drives, needs and interests

(3) Self-concepts, aspiration and goal setting

(4) Process of reconstructing experience into knowlegde: facts, concepts, values and attitudes.

(5) Possibilities and nature of behavior and skill modification

(6) The process of cognitive and affective development

(7) Effects of environment on competence and creativity of students

6. Competence on Evaluation

(1) Evaluation design

a. Evaluation policies

b. Evaluation assumption

c. Collection of data

d. Analysis of data

e. Dissemination of information

(2) Program rationale

a. School organization and management of evaluation

b. Student and teacher characteristic test items, questionaire, curricular contest and evaluation content and method

c. Instructional materials and its influence upon student's achievements

(3) Transactions

a. Social climate

b. Communication flow

c. Sequence of events

d. Time allocation of tests and questionaire

e. Reinforcement plan of evaluation

(4) Outcome

a. Student's achievement, attitudes, skills

b. Effects on teachers

c. Instructional effects

d. Environmental effects in social education and family education

(5) Stages of evaluation

a. Design adequacy

b. Installation fidelity

c. Process adjustment

d. Product assessment

e. Cost-benefit-analysis

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